

Docket No.: 1793.1209

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of:

Sung-hee HWANG et al.

Application No. 10/804,016

Group Art Unit: 2627

Confirmation No. 8198

Filed: March 19, 2004

Examiner: Jorge L. Ortiz Criado

For: METHOD OF MANAGING DEFECTS FOR A WRITE-ONCE RECORDING MEDIUM, REPRODUCING AND/OR RECORDING APPARATUS IMPLEMENTING THE SAME, A CORRESPONDING WRITE-ONCE RECORDING MEDIUM THEREFOR, AND MEDIUM INCLUDING COMPUTER READABLE CODE CONTROLLING THE IMPLEMENTATION OF THE SAME

SUBMISSION OF VERIFIED TRANSLATION OF PRIORITY DOCUMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Applicants submit herewith a translation of Korean Patent Application No. 2003-24869 claiming priority to April 19, 2003 and a statement from the translator.

If there are any fees associated with filing of this Submission, please charge the same to our Deposit Account No. 503333.

Respectfully submitted,

STEIN, MCEWEN & BUI, LLP

Date: 10/24/03

By: G. Clinton
Gregory L. Clinton
Registration No. 59,134

1400 Eye St., N.W., Suite 300
Washington, D.C. 20005
Telephone: (202) 216-9505
Facsimile: (202) 216-9510

CERTIFICATION OF TRANSLATION

I, Joo-hyun Hong, an employee of Y.P. LEE, MOCK & PARTNERS of The Goryo Bldg.,
1575-1 Seocho-dong, Seocho-gu, Seoul, Republic of Korea, hereby declare under penalty of perjury that I understand the Korean language and the English language; that I am fully capable of translating from Korean to English and vice versa; and that, to the best of my knowledge and belief, the statement in the English language in the attached translation of Korean Patent Application No. 10-2003-0024869 consisting of 40 pages, have the same meanings as the statements in the Korean language in the original document, a copy of which I have examined.

Signed this 21st day of October 2008

Hong Joo-hyun

ABSTRACT

[Abstract of the Disclosure]

5 Provided are a method of managing defects considering compatibility with a
rewritable disc, and a disc drive and write-once disc therefor. The method includes
providing a plurality of temporary defect management areas on the write-once disc;
performing defect management using the plurality of temporary defect management
areas; and when one among the plurality of temporary defect management areas is
exhausted, writing full flag information indicating that the one temporary defect
10 management area is exhausted to at least one among remaining temporary defect
management areas. Accordingly, defect management can be efficiently performed.

[Representative Drawing]

FIG. 5A

SPECIFICATION

[Title of the Invention]

5 Method for managing defect considering compatability with a rewritable disc, a disc drive and a write once disc thereof

[Brief Description of the Drawings]

FIG. 1 is a block diagram of an apparatus for performing defect management
10 according to an embodiment of the present invention;

FIG. 2 is a block diagram of a disc drive in which the apparatus shown in FIG. 1 is implemented;

FIGS. 3A and 3B are diagrams illustrating structures of a disc on which a plurality of temporary defect management areas are allocated, according to embodiments of the
15 present invention;

FIG. 4 is a diagram illustrating a structure of a disc on which a plurality of temporary defect management areas are allocated, according to another embodiment of the present invention;

FIGS. 5A and 5B are diagrams illustrating information written to a temporary
20 defect management area, according to embodiments of the present invention;

FIGS. 6A and 6B are diagrams illustrating data structures of a temporary defect management area, according to embodiments of the present invention;

FIG. 7 is a diagram illustrating an operation of writing data to a user data area and a spare area, according to an embodiment of the present invention;

25 FIG. 8 is a diagram illustrating data structures of TDFL #1 and TDFL #2, respectively, written to a first temporary defect management area, according to an embodiment of the present invention;

FIG. 9 is a diagram illustrating data structures of TDFL #1, TDFL #2, and TDFL #3, respectively, written to a second temporary defect management area, according to an embodiment of the present invention; and

FIG. 10 is a diagram illustrating a data structure of information on Defect #i shown in FIGS. 8 and 9.

[Detailed Description of the Invention]

[Object of the Invention]

[Technical Field of the Invention and Related Art prior to the Invention]

The present invention relates to technology of managing defects on a write-once disc, and more particularly, to a method of managing defects considering compatibility with a rewritable disc, and a disc drive and write-once disc therefor.

Defect management is a process of re-writing user data to a user data area when the user data that has been recorded in the user data area has a defect so as to compensate for data loss due to the defect. Conventionally, defect management is performed using linear replacement or slipping replacement. Linear replacement is a process of replacing a defective sector in a user data area by a sector having no defects in a spare area. Slipping replacement is a process of skipping a defective sector and using the first good sector immediately following the defective sector.

Both of linear replacement and slipping replacement can be used only for discs such as DVD-RAM discs and DVD-RW discs to which data can be rewritten and to which data can be written using random access. In other words, it is difficult to apply conventional linear replacement and slipping replacement to write-once discs for writing just once. Whether a defect has occurred can be verified by actually writing data to a disc. However, since data cannot be re-written to write-once discs, defect management cannot be performed on write-once discs using conventional methods.

Meanwhile, high-density write-once discs having a capacity of a several tens of GB have been developed following CD-R and DVD-R discs. These discs are inexpensive and enable data to be read using random access, thereby having a fast

reading speed, and therefore, they are usually used for backup. However, since defect management is not performed on write-once discs, backup is interrupted when a defective sector occurs during the backup. In particular, since backup is usually performed while a system is not frequently used, i.e., during the night while an operator is absent, the likelihood that backup is left interrupted without being resumed is very high.

Thus the applicant has filed patent applications on various inventions including a defect management method in which a defect management area and a temporary defect management area are formed in a recording disk, and an apparatus and a disk therefor. One of the filed patent applications is Korean Patent Application No. 2002-61897 filed on October 10, 2002.

Conventionally, positional information of areas provided for defect management is disclosed in specifications, and disc drive designers design disc drives based on the specifications. Accordingly, if new areas are added to a disc besides areas for conventional defect management, a conventional disc drive cannot properly recognize the new areas, and defect management cannot be performed properly.

[Technical Goal of the Invention]

The present invention provides a method of managing defects on a write-once disc to allow recording to be smoothly performed on the write-once disc, and a disc drive and write-once disc therefor.

The present invention also provides a method of managing defects on a write-once disc to have compatibility with a rewritable disc drive, and a disc drive and write-once disc therefor.

[Structure and Operation of the Invention]

According to an aspect of the present invention, there is provided a method of managing defects on a write-once disc. The method includes providing a plurality of temporary defect management areas on the write-once disc; performing defect

management using the plurality of temporary defect management areas; and when one among the plurality of temporary defect management areas is exhausted, writing full flag information indicating that the one temporary defect management area is exhausted to at least one among remaining temporary defect management areas.

5 The method may further comprise performing the defect management using the remaining temporary defect management areas.

 The providing of the plurality of temporary defect management areas may comprise: disposing at least one among the plurality of temporary defect management areas in at least one among a lead-in area, a lead-out area, and an outer area; and
10 disposing at least one among the plurality of temporary defect management areas in a data area.

 The performing defect management may comprise, when one among temporary defect management areas disposed in at least one among the lead-in area, the lead-out area, and the outer area is exhausted, writing full flag information indicating that the one
15 temporary defect management area is exhausted to at least one among temporary defect management areas disposed in the data area.

 The performing defect management may comprise, when one among temporary defect management areas disposed in the data area is exhausted, writing full flag information indicating that the one temporary defect management area is exhausted to
20 at least one among temporary defect management areas disposed in at least one among the lead-in area, the lead-out area, and the outer area.

 According to another aspect of the present invention, there is provided a method of managing defects on a write-once disc having a single recording layer on which a lead-in area, a data area, and a lead-out area are sequentially disposed, the data area
25 having a first spare area and a second spare area at the respective opposite ends thereof. The method includes allocating a first temporary defect management area to at least one of the lead-in area and the lead-out area of the write-once disc; allocating a second temporary defect management area between the first spare area and a user data area or between the user data area and the second spare area; performing defect

management using the first and second temporary defect management areas; and when one of the first and second temporary defect management areas is exhausted, writing full flag information indicating that the one of the first and second temporary defect management areas is exhausted to the other one of the first and second temporary defect management areas.

According to still another aspect of the present invention, there is provided a method of managing defects on a write-once disc having a first recording layer and a second recording layer, the first recording layer including a lead-in area, a data area, and an outer area which are sequentially disposed according to a recording path wherein the data area has a first spare area and a second spare area at the respective opposite ends thereof, the second recording layer including an outer area, a data area, and a lead-in area which are sequentially disposed according to the recording path wherein the data area has a third spare area and a fourth spare area at the respective opposite ends thereof. The method includes allocating a first temporary defect management area to at least one among the lead-in area, the lead-out area, and the outer areas of the write-once disc; allocating a second temporary defect management area between the first spare area and a user data area and/or between the fourth spare area and the user data area; performing defect management using the first and second temporary defect management areas; and when one of the first and second temporary defect management areas is exhausted, writing full flag information indicating that the one of the first and second temporary defect management areas is exhausted to the other one of the first and second temporary defect management areas.

The method may further comprise performing the defect management using the other one of the first and second temporary defect management areas.

The performing of the defect management may comprises: updating temporary management information in the second temporary defect management area whenever a predetermined number of clusters in the user data area are filled or whenever verify-after-write is completed a predetermined number of times; and updating

temporary management information in the first temporary defect management area whenever a recording operation is completed.

The performing of the defect management may comprise writing the most update temporary management information in the first or second temporary defect management area to a defect management area provided in at least one of the lead-in area and the lead-out area of the write-once disc.

According to still another aspect of the present invention, there is provided a disc drive including a pickup which writes data to or reads data from a disc; and a control unit which verifies data that is written to or read from the disc by the pickup, performs defect management using a plurality of temporary defect management areas provided on the disc, and when one among the plurality of temporary defect management areas is exhausted, controls the pickup to write full flag information indicating that the one temporary defect management area is exhausted to at least one among remaining temporary defect management areas.

The control unit may perform the defect management using the remaining temporary defect management areas.

When one among temporary defect management areas disposed in at least one among the lead-in area, the lead-out area, and the outer area is exhausted, the control unit may control the pickup to write full flag information indicating that the one temporary defect management area is exhausted to at least one among temporary defect management areas disposed in the data area.

When one among the temporary defect management areas disposed in the data area is exhausted, the control unit may control the pickup to write full flag information indicating that the one temporary defect management area is exhausted to at least one among the temporary defect management areas disposed in at least one among the lead-in area, the lead-out area, and the outer area.

According to still another aspect of the present invention, there is provided a write-once disc having a single recording layer on which a lead-in area, a data area, and a lead-out area are sequentially disposed, the data area having a first spare area, a

user data area, and a second spare area which are sequentially disposed. The write-once disc includes a defect management area provided in at least one of the lead-in area and the lead-out area to write defect management information; a first temporary defect management area provided in at least one of the lead-in area and the lead-out area to write temporary management information with a predetermined period; and a second temporary defect management area provided between the first spare area and the user data area or between the user data area and the second spare area to write temporary management information with a different period from the predetermined period. Here, full flag information indicating whether the second temporary defect management area is exhausted is written to the first temporary defect management area, and full flag information indicating whether the first temporary defect management area is exhausted is written to the second temporary defect management area.

According to still another aspect of the present invention, there is provided a write-once disc having a first recording layer and a second recording layer, the first recording layer including a lead-in area, a data area, and an outer area which are sequentially disposed according to a recording path wherein the data area has a first spare area and a second spare area at the respective opposite ends thereof, the second recording layer including an outer area, a data area, and a lead-in area which are sequentially disposed according to the recording path wherein the data area has a third spare area and a fourth spare area at the respective opposite ends thereof. The write-once disc includes a defect management area provided in at least one among the lead-in area, the lead-out area, and the outer areas to write defect management information; a first temporary defect management area provided in at least one among the lead-in area, the lead-out area, and the outer areas to write temporary management information with a predetermined period; and a second temporary defect management area provided between the first spare area and the user data area and/or between the fourth spare area and the user data area to write temporary management information with a different period from the predetermined period. Here, full flag information indicating whether the second temporary defect management area is exhausted is

written to the first temporary defect management area, and full flag information indicating whether the first temporary defect management area is exhausted is written to the second temporary defect management area.

5 The temporary management information in the second temporary defect management area may be updated whenever a predetermined number of clusters in the user data area are filled or whenever verify-after-write is completed a predetermined number of times.

The temporary management information in the first temporary defect management area may be updated whenever a recording operation is completed.

10 The most update temporary management information in the first or second temporary defect management area may be written to the defect management area when the write-once disc is finalized.

Hereinafter, preferred embodiments of the present invention will be described in detail with reference to the attached drawings.

15 FIG. 1 is a block diagram of an apparatus for performing defect management according to an embodiment of the present invention. Referring to FIG. 1, the apparatus includes a writing/reading unit 1, a control unit 2, and a memory unit 3. The writing/reading unit 1 writes data to a disc 100, i.e., information storage medium according to an embodiment of the present invention, and reads the data in order to
20 verify the written data. The control unit 2 performs defect management according to the present invention. In other words, the control unit 2 performs defect management using a plurality of temporary defect management areas provided in different types of area on the disc 100. When one of two temporary defect management areas is filled with temporary management information, the control unit 2 writes the fact that one
25 temporary defect management area is full to the other temporary defect management area so that a disc drive can recognize that the one temporary defect management area has been exhausted, thereby providing reliability of the system. Thereafter, the control unit 2 performs defect management using only the other temporary defect management area.

In the embodiment of the present invention, the control unit 2 uses verify-after-write in which data is written in predetermined units and the written data is verified to detect defects. The control unit 2 writes user data in predetermined units and verifies the user data to detect a defective sector. The control unit 2 generates defect information indicating a position of the detected defective sector. The control unit 2 stores defect information in the memory unit until a predetermined amount of defect information is collected and writes the collected defect information to two temporary defect management areas provided on the disc 100 according to the present invention. Information written to a temporary defect management area is referred to as temporary management information to be distinguished from management information written to a defect management area for defect management. The two temporary defect management areas have different periods with which temporary management information is written.

Whenever a predetermined number of clusters in a data area on the disc 100 is filled or when verification is completed after at least one writing, the control unit 2 reads defect information from the memory unit 3, provides the defect information to the writing/reading unit 1, and writes the defect information to one temporary defect management area as temporary management information. Furthermore, when a user presses an eject button (not shown) on the apparatus to take out the disc 100 after predetermined data is completely written to the disc 100, the control unit 2 predicts that one recording operation will end. Then, the control unit 2 reads defect information from the memory unit 3, provides it to the writing/reading unit 1, and commands the writing/reading unit 1 to write it to another temporary defect management area.

During defect management, when at least one temporary defect management area is used and no more information can be written thereto, the control unit 2 writes full flag information, which indicates the fact that no more information can be written to the at least one temporary defect management area, to at least one other temporary defect management area. After writing the full flag information, the control unit 2 writes

temporary management information only to the other temporary defect management areas.

When data is completely written to the disc 100, that is, when the disc 100 is finalized so as to terminate data recording, the control unit 2 writes the most updated temporary management information on the disc 100 to a defect management area on the disc 100.

Generally, a defect management area allocated to a rewritable disc is not very large. Accordingly, if a write-once disc is provided with a defect management area having the same size at the same position as a rewritable disc, considering only compatibility, the defect management area is exhausted before data is written to the write-once disc, and defect management cannot be performed. To overcome this problem, in the present invention, a plurality of temporary defect management areas are separately provided in different types of areas in addition to the defect management area, and final effective information is written to the defect management area in response to a user's command or finalization. Accordingly, a write-once disc according to the present invention can be recognized properly by a drive for rewritable discs. In other words, according to the present invention, a write-once disc is allocated a plurality of temporary defect management areas in different types of areas not to influence other areas defined on a rewritable disc, thereby allowing defect management and having compatibility with a drive for rewritable discs having a defect management area. Furthermore, when one of a plurality of temporary defect management areas having different periods, with which temporary management information is written, is exhausted, full flag information is written to other temporary defect management areas so that defect management is performed efficiently.

FIG. 2 is a block diagram of a disc drive in which the apparatus shown in FIG. 1 is implemented. Referring to FIG. 2, the disc drive includes a pickup 10 as the writing/reading unit 1. The disc 100 is loaded in the pickup 10. The disc drive includes the control unit 2 including a personal computer interface (PC I/F) 21, a digital signal processor (DSP) 22, a radio frequency amplifier (RF AMP) 23, a servo 24, and a

system controller 25. The memory unit 3 is provided in the system controller 25 of the control unit 2.

During recording, the PC I/F 21 receives a write command together with data to be written from a host (not shown). The system controller 25 performs initialization for recording. The DSP 22 performs error correction coding (ECC) by adding additional data such as parity for error correction to the data received from the PC I/F 21 and modulates the error correction coded data according to a predetermined method. The RF AMP 23 converts the data output from the DSP 22 into an RF signal. The pickup 10 writes the RF signal output from the RF AMP 23 to the disc 100. The servo 24 receives commands necessary for servo control from the system controller 25 and performs servo control on the pickup 10. In addition, to perform defect management during recording according to the present invention, the system controller 25 commands the pickup 10 to read the written data or to write predetermined information such as temporary management information.

During playback, the PC I/F 21 receives a playback command from the host. The system controller 25 performs initialization for playback. The pickup 10 radiates a laser beam onto the disc 100, then receives the laser beam reflected from the disc 100, and then outputs a light signal obtained from the received laser beam. The RF AMP 23 converts the light signal output from the pickup 10 into an RF signal, provides modulated data obtained from the RF signal to the DSP 22, and provides a servo signal obtained from the RF signal for control to the servo 24. The DSP 22 demodulates the modulated data, performs ECC on the demodulated data, and outputs data resulting from the ECC. Meanwhile, the servo 24 receives the servo signal from the RF AMP 23 and a command necessary for servo control from the system controller 25 and performs the servo control on the pickup 10. The PC I/F 21 transmits the data received from the DSP 22 to the host. In addition, the system controller 25 can command the pickup 10 to read information necessary for defect management. In other words, the system controller 25 entirely manages a system during recording and playback.

FIGS. 3A and 3B are diagrams illustrating structures of the disc 100 on which a plurality of temporary defect management areas are allocated, according to embodiments of the present invention. Referring to FIGS. 3A and 3B, the disc 100 is a single-layer disc having a single recording layer L0 and includes a lead-in area, a data area, and a lead-out area. The lead-in area is positioned at the inner diameter of the disc 100, and the lead-out area is positioned at the outer diameter of the disc 100. The data area is positioned between the lead-in area and the lead-out area. The start and the end of the data area on the disc 100 according to the present invention are the same as those on a rewritable disc. The data area is divided into a first spare area, a user data area, and a second spare area sequentially from the inner diameter toward the outer diameter. User data is written to the user data area. The first and second spare areas are provided to compensate for loss of recording space due to defects in the user data area. Preferably, the first and second spare areas are set to secure a maximum data capacity allowable when considering defects on the disc 100.

A defect management area is provided in the lead-in area on the disc 100 at the same position as that on a rewritable disc. Like on the rewritable disc on which defect management can be performed, the defect management area on the disc 100 includes size information of the first spare area, start position information of the user data area, end position information of the user data area, and size information of the second spare area. Accordingly, the disc drive knowing the start and the end of the data area becomes to know the start and end positions of the user data area by reading the information from the defect management area and recognizes the first and second spare areas based on the position and size information.

A first temporary defect management area is provided in the lead-in area, and a second temporary defect management area is provided in the data area. The second temporary defect management area is allocated between the first spare area and the user data area in the data area on the disc 100 according to a user's option at the initialization of recording/playback or provides by default. Even when the second

temporary defect management area is newly allocated, the start and the end of the data area do not change.

The first temporary defect management area is updated at each recording operation. The second temporary defect management area is updated whenever as
5 much information as corresponding to a predetermined number of clusters is written or whenever verify-after-write is completed at least one time. Accordingly, the second temporary defect management area is more frequently updated than the first temporary defect management area and thus needs wider physical area than the first temporary defect management area. Accordingly, the first temporary defect management area
10 requiring a relatively small area is provided in the lead-in area or the lead-out area while the second temporary defect management area requiring a relatively large area is provided in the data area.

Referring to FIG. 3A, the second temporary defect management area is allocated between the first spare area and the user data area in the data area on the disc 100
15 according to a user's option at the initialization or provides by default.

Referring to FIG. 3B, the second temporary defect management area is allocated between the user data area and the second spare area in the data area on the disc 100 according to a user's option at the initialization of recording/playback or provides by default.

20 Temporary management information is written to the first and second temporary defect management areas. Temporary management information includes temporary defect information and management information for managing the temporary defect information.

Providing the first temporary defect management area together with the second
25 temporary defect management area offers the following advantages. Since the first temporary defect management area is updated at each recording operation, when power is turned off during a recording operation, that is, while a disc drive is temporarily storing updated temporary management information and is standing by for another recording, the updated temporary management information is lost, which may cause a

problem in using the disc 100 later. However, since the second temporary defect management area is updated whenever verify-after-write is completed, a problem caused by power interruption of the disc drive during the standby for recording, i.e., loss of information or damage to the disc 100 due to the information loss, can be prevented.

5 In addition, since an integer number of verifications are performed at each recording operation, when the first temporary defect management area is updated whenever verify-after-write is completed, final effective information is recorded in the first and second temporary defect management areas at the end of a recording operation so that robustness of information can be increased. As described above, the second
10 temporary defect management area solves a problem that may occur due to power interruption in a recording standby mode, and simultaneously increases robustness of information.

A rewritable disc drive recognizes the first and second spare areas based on position information written to the defect management area. Since the positions of the
15 first and second spare areas on a write-once disc having the structure shown in FIG. 3A or 3B do not change, when the write-once disc is inserted into the rewritable disc drive, information that has been re-written to the first and second spare areas according to defect management can be correctly read, and the start and the end of the user data area can be correctly recognized based on the position information in the defect
20 management area. As a result, a problem of erroneous recognition of an area does not occur when playback is performed in response to a command from the host.

FIG. 4 is a diagram illustrating a structure of the disc 100 on which a plurality of temporary defect management areas are allocated, according to another embodiment of the present invention. Referring to FIG. 4, the disc 100 is a double-layer disc having
25 recording layer L0 and L1. In the recording layer L0, a lead-in area, a data area, and an outer area are sequentially disposed from the inner diameter to the outer diameter of the disc 100. In the recording layer L1, an outer area, a data area, and a lead-out area are sequentially disposed from the outer diameter to the inner diameter of the disc 100. Unlike the single-layer discs shown in FIGS. 3A and 3B, the lead-out area is disposed at

the inner diameter of the disc 100. In other words, recording is performed according to an opposite track path (OTP) from the lead-in area in the recording layer L0 to the outer area in the recording layer L0 and then from the outer area in the recording layer L1 to the lead-out area of the recording layer L1. Two spare areas are allocated to each of the recording layers L0 and L1, and therefore, four spare areas, i.e., first through fourth spare areas, are allocated to the disc 100.

A defect management area and a first temporary defect management area are provided in one or both of the lead-in area and the lead-out area. The defect management area is disposed at the same position as that on a rewritable disc. The first temporary defect management area is disposed not to change the positions of the lead-in and lead-out areas defined on a conventional write-once disc or a rewritable disc. One or both of the defect management area and the first temporary defect management area can be disposed in the outer area.

Like on the rewritable disc on which defect management can be performed, the defect management area on the disc 100 shown in FIG. 4 includes size information of the first spare area, start position information of the user data area, end position information of the user data area, size information of the second spare area plus the third spare area, and size information of the fourth spare area. Accordingly, the disc drive knowing the start and the end of the data area becomes to know the start and end positions of the user data area by reading the information from the defect management area and recognizes the first through fourth spare areas based on the position and size information. Here, the second spare area has the same size as the third spare area.

The second temporary defect management area is disposed between the first spare area 1 and the user data in the recording layer L0 and is disposed between the user data area and the fourth spare area in the recording layer L1. The start and end of the data area in each of the recording layers L0 and L1 are the same as those shown in FIGS. 3A and 3B. With such arrangement, each area on the write-once disc 100 having two recording layers according to this embodiment of the present invention can be correctly recognized by a drive for rewritable discs having two recording layers.

When the position of the second temporary defect management area changes in the data area, the drive for rewritable discs having two recording layers cannot properly recognize each area on the disc 100. The reason has been described above with reference to FIGS. 3A and 3B.

5 FIGS. 5A and 5B are diagrams illustrating information written to a temporary defect management area, according to embodiments of the present invention. Referring to FIG. 5A, each of a plurality of temporary defect management areas includes full flag information. The full flag information indicates that a certain temporary defect management area is exhausted and does not allow temporary
10 management information to be written thereto any more.

 Referring to FIG. 5B, in an embodiment of the present invention, the second temporary defect management area includes full flag information indicating that the first temporary defect management area is exhausted and does not allow temporary management information to be written thereto any more, position and size information of
15 the first temporary defect management area, and position information of last temporary management information written to the first temporary defect management area. The position and size information of the first temporary defect management area indicates the position and the size of the first temporary defect management area. The position information of the last temporary management information written to the first temporary
20 defect management area indicates the position of temporary management information that was last written to the first temporary defect management area.

 FIGS. 6A and 6B are diagrams illustrating data structures of a temporary defect management area, according to embodiments of the present invention. Referring to FIG. 6A, the temporary defect management area is logically divided into a temporary
25 defect information area and a temporary defect management information area. Temporary defect information TDFL #1, TDFL #2, TDFL #3 and the like are sequentially written to the temporary defect information area from the front portion thereof. Temporary defect management information TDDS #1, TDDS #2, TDDS #3, and the like are sequentially written to the temporary defect management information area from the

front portion thereof. The temporary defect management information TDDS #1, TDDS #2, and TDDS #3 correspond to the temporary defect information TDFL #1, TDFL #2, and TDFL #3. In this embodiment of the present invention, the full flag information is written in the form of a field as an element of the temporary defect management information. For example, when a certain temporary defect management area is exhausted and does not allow temporary management information to be written thereto any more, a full flag changes from 0 to 1.

Alternatively, the temporary defect information TDFL #1, TDFL #2, TDFL #3 and the like may be sequentially written to the temporary defect information area from the back portion thereof. The temporary defect management information TDDS #1, TDDS #2, TDDS #3, and the like may be sequentially written to the temporary defect management information area from the back portion thereof. The full flag information may be written in the form of a field as an element of the temporary defect management information. For example, when a certain temporary defect management area is exhausted and does not allow temporary management information to be written thereto any more, a full flag changes from 0 to 1.

Referring to FIG. 6B, temporary defect information and corresponding temporary defect management information are written in pair to a temporary defect management area. In other words, temporary management information TDMA #1, TDMA #2, and the like are sequentially written to the temporary defect management area from the front portion thereof. The temporary management information TDMA #1 includes temporary defect information TDFL #1 and corresponding temporary defect management information TDDS #1, and the temporary management information TDMA #2 includes temporary defect information TDFL #2 and corresponding temporary defect management information TDDS #2.

In this embodiment of the present invention, the full flag information is written in the form of a field as an element of the temporary defect management information. For example, when a certain temporary defect management area is exhausted and does not

allow temporary management information to be written thereto any more, a full flag changes from 00h to 01h.

Alternatively, the temporary management information TDMA #1, TDMA #2, and the like may be sequentially written to the temporary defect management area from the back portion thereof. The full flag information may be written in the form of a field as an element of the temporary defect management information. For example, when a certain temporary defect management area is exhausted and does not allow temporary management information to be written thereto any more, a full flag changes from 00h to 01h.

FIG. 7 is a diagram illustrating an operation of writing data to a user data area A and a spare area B, according to an embodiment of the present invention. Referring to FIG. 7, each of the user data area A and the spare area A includes a plurality of physical sectors (not shown) to which physical sector numbers are sequentially allocated, respectively. A logical sector number is allocated to at least one physical sector. However, since a logical sector number is allocated to a replacement sector in the spare area B excluding a defective sector in the user data area A, even though it is presumed that the size of a physical sector is the same as that of a logical sector, a physical sector number may not identical to a logical sector number.

Circled numerals ① through ⑦ denote sections, respectively, on which verify-after-write is performed. A disc drive writes user data to the section ①, then goes back to the beginning of the section ①, and then verifies whether the user data has been correctly written to the section ① or a defect has occurred in the section ①. When a defect is found, a sector having the defect is defined as a defective sector, for example, Defect #1. In addition, the disc drive re-writes data written to Defect #1 to the spare area B. A sector to which the data written to Defect #1 is re-written in the spare area B is referred to as Replacement #1.

Under the condition that the second temporary defect management area is updated whenever verify-after-write is completed, the disc drive writes information on Defect #1 and information on Replacement #1 together as TDFL #1 to the second

temporary defect management area. In addition, the disc drive writes management information for managing TDFL #1 to the second temporary defect management area as TDDS #1.

Next, the disc drive writes user data to the section ②, then goes back to the beginning of the section ②, and then verifies whether the user data has been correctly written to the section ② or a defect has occurred in the section ②. When a defect is found, a sector having the defect is defined as Defect #2. In the same manner as described above, Replacement #2 corresponding to Defect #2 is generated. Information on Defect #2 and information on Replacement #2 are together written as TDFL #2 to the second temporary defect management area. In addition, management information for managing TDFL #2 is written as TDDS #2 to the second temporary defect management area.

With respect to the section ③, Defect #3 and Replacement #3 are generated. With such manner, the second temporary defect management area is updated. In the section ④, a defective sector is not defined since a defect is not found. After the verify-after-write is completed with respect to the section ④, when termination of Recording operation #1 is predicted, i.e., when a user presses an eject button or when user data corresponding to a recording operation is completely written, information on Defects #1, #2, and #3 that are defective sectors found among the sections ① through ④ is written as first temporary management information, i.e., TDFL #1, to the first temporary defect management area. In addition, management information for managing TDFL #1 written to the first temporary defect management area is written as TDDS #1 to the first temporary defect management area.

When Recording operation #2 starts, Defect #4, Replacement #4, Defect #5, and Replacement #5 are generated while user data is written to the sections ⑤ through ⑦, in the same manner as described above. Whenever the verify-after-write is completed, the second temporary defect management area is updated. When termination of Recording operation #2 is predicted, the disc drive writes information on Defects #4 and

#5 and TDFL #1 written to the first temporary defect management area together as second temporary defect information, i.e., TDFL #2, to the first temporary defect management area. In addition, the disc drive writes management information for managing TDFL #2 to the first temporary defect management area as TDDS #2.

5 FIG. 8 is a diagram illustrating data structures of TDFL #1 and TDFL #2, respectively, written to the first temporary defect management area, according to an embodiment of the present invention. Referring to FIG. 8, TDFL #1 in the first temporary defect management area includes the information on Defects #1, #2, and #3. The information on Defect #1 includes the position of Defect #1 and the position of
10 Replacement #1. The information on Defect #2 includes the position of Defect #2 and the position of Replacement #2. The information on Defect #3 includes the position of Defect #3 and the position of Replacement #3.

TDFL #2 in the first temporary defect management area includes the information included in TDFL #1 and information on the information on Defects #4 and #5. In other
15 words, TDFL #2 includes the information on Defects #1, #2, #3, #4, and #5.

FIG. 9 is a diagram illustrating data structures of TDFL #1, TDFL #2, and TDFL #3, respectively, written to the second temporary defect management area, according to an embodiment of the present invention.

Referring to FIG. 9, in the second temporary defect management area, TDFL #1
20 includes the information on Defect #1, TDFL #2 includes the information on Defects #1 and #2, and TDFL #3 includes the information on Defects #1, #2, and #3.

FIG. 10 is a diagram illustrating a data structure of information on Defect #i shown in FIGS. 8 and 9. Referring to FIG. 10, the information on Defect #i includes Defect #i pointer and Replacement #i pointer. The Defect #i pointer indicates the start
25 and end positions of Defect #i. The Replacement #i pointer indicates the start and end positions of Replacement #i.

The following description concerns a method of managing defects on the write-once disc 100 having the first and second temporary defect management areas, as shown in FIG. 3A, 3B, or 4.

Defect management is performed according to linear replacement. Defect management results are written as temporary management information to the first and second temporary defect management areas with different periods. The temporary management information includes temporary defect information and temporary defect management information. The temporary defect information indicates the position of a defective sector and the position of a replacement sector for the defective sector. The temporary defect management information is used to manage the temporary defect information and includes information indicating a position where the temporary defect information is written.

In an embodiment of the present invention, temporary defect information and temporary defect management information are written to the second temporary defect management area according to a write period, i.e., whenever a predetermined number of clusters are filled in the user data area or whenever verify-after-write is performed at least one time. Temporary defect information and temporary defect management information are written to the first temporary defect management area whenever a recording operation is terminated. Writing new temporary defect information and new temporary defect management information to an area is referred to an update of the area.

Most recently written temporary defect information and temporary defect management information, i.e., most update temporary management information is written to a defect management area in response to a user's command or when finalization is performed. The most update temporary management information is written to the defect management area for the following reasons. Writing the most update temporary management information including temporary defect information and temporary defect management information to the defect management area when data will not be recorded on the disc 100 any more, e.g., when the disc 100 is finalized, allows a recording or playback apparatus to quickly read information from the disc 100. In addition, writing the defect management information to a plurality of places increases reliability of information.

<Case where the first temporary defect management area is exhausted first>

The first temporary defect management area is updated whenever a recording operation is completed. If a user enters an eject command, the last temporary management information in the second temporary defect management area is written to the first temporary defect management area because the second temporary defect management area is updated whenever verify-after-write is completed and the verify-after-write is usually performed multiple times during one recording operation. However, the first temporary defect management area may not have enough space to write temporary management information thereto. Accordingly, when the disc 100 is inserted into a disc drive, available space of the first temporary defect management area is checked to determine whether the first temporary defect management area can be used. When it is determined that the first temporary defect management area cannot be used because it is completely exhausted or does not have sufficient space, defect management is performed using only the second temporary defect management area. In this situation, the disc drive writes full flag information indicating the first temporary defect management area is full and cannot be used when updating the second temporary defect management area. Thereafter, when the disc 100 is re-inserted into a disc drive, the disc drive recognizes that the first temporary defect management area cannot be used based on the full flag information and updates only the second temporary defect management area.

<Case where the second temporary defect management area is exhausted first>

Since the second temporary defect management area is updated whenever verify-after-write is completed, it can be exhausted completely during recording or playback. Accordingly, when a defect occurs or temporary management information needs to be updated after verify-after-write since the second temporary defect management area was exhausted completely, the second temporary defect management area cannot be updated. In this situation, the disc drive shown in FIG. 2 stores update information for the second temporary defect management area in the memory unit 3 and writes the update information to the first temporary defect

management area when the first temporary defect management area is updated, i.e., when a recording operation is completed. When writing the update information to the first temporary defect management area, the disc drive also writes full flag information indicating that the second temporary defect management area is completely exhausted
5 to the first temporary defect management area. Thereafter, defect management is performed using only the first temporary defect management area. In other words, temporary management information is written to the first temporary defect management area whenever a recording operation is completed.

10 [Effect of the Invention]

According to the present invention, a plurality of temporary defect management areas are allocated to a write-once disc for defect management, and update information is written to a defect management area in response to a user's command or finalization, so that the write-once disc can be correctly played back by a drive for a rewritable disc.

15 In addition, when at least one among the plurality of temporary defect management areas is exhausted, this fact is written as full flag information to at least one among the remaining temporary defect management areas so that the disc drive recognizes this fact and does not write temporary management information to the exhausted area any more. As a result, reliability of a system can be secured.

What is claimed is:

1. A method of managing defects on a write-once disc, the method comprising:
providing a plurality of temporary defect management areas on the write-once
5 disc;

performing defect management using the plurality of temporary defect management areas; and

when one among the plurality of temporary defect management areas is exhausted, writing full flag information indicating that the one temporary defect
10 management area is exhausted to at least one among remaining temporary defect management areas.

2. The method of claim 1, further comprising performing the defect management using the remaining temporary defect management areas.

15

3. The method of claim 1, wherein the providing of the plurality of temporary defect management areas comprises:

disposing at least one among the plurality of temporary defect management areas in at least one among a lead-in area, a lead-out area, and an outer area; and

20 disposing at least one among the plurality of temporary defect management areas in a data area.

4. The method of claim 3, wherein the writing of the full flag information comprises, when one among temporary defect management areas disposed in at least
25 one among the lead-in area, the lead-out area, and the outer area is exhausted, writing full flag information indicating that the one temporary defect management area is exhausted to at least one among temporary defect management areas disposed in the data area.

5. The method of claim 3, wherein the writing of the full flag information comprises, when one among temporary defect management areas disposed in the data area is exhausted, writing full flag information indicating that the one temporary defect management area is exhausted to at least one among temporary defect management areas disposed in at least one among the lead-in area, the lead-out area, and the outer area.

6. A method of managing defects on a write-once disc having a single recording layer on which a lead-in area, a data area, and a lead-out area are sequentially disposed, the data area having a first spare area and a second spare area at the respective opposite ends thereof, the method comprising:

- allocating a first temporary defect management area to at least one of the lead-in area and the lead-out area of the write-once disc;
- allocating a second temporary defect management area between the first spare area and a user data area or between the user data area and the second spare area;
- performing defect management using the first and second temporary defect management areas; and
- when one of the first and second temporary defect management areas is exhausted, writing full flag information indicating that the one of the first and second temporary defect management areas is exhausted to the other one of the first and second temporary defect management areas.

7. The method of claim 6, further comprising performing the defect management using the other one of the first and second temporary defect management areas.

8. A method of managing defects on a write-once disc having a first recording layer and a second recording layer, the first recording layer including a lead-in area, a data area, and an outer area which are sequentially disposed according to a

recording path wherein the data area has a first spare area and a second spare area at the respective opposite ends thereof, the second recording layer including an outer area, a data area, and a lead-in area which are sequentially disposed according to the recording path wherein the data area has a third spare area and a fourth spare area at the respective opposite ends thereof, the method comprising:

allocating a first temporary defect management area to at least one among the lead-in area, the lead-out area, and the outer areas of the write-once disc;

allocating a second temporary defect management area between the first spare area and a user data area and/or between the fourth spare area and the user data area;

performing defect management using the first and second temporary defect management areas; and

when one of the first and second temporary defect management areas is exhausted, writing full flag information indicating that the one of the first and second temporary defect management areas is exhausted to the other one of the first and second temporary defect management areas.

9. The method of claim 8, further comprising performing the defect management using the other one of the first and second temporary defect management areas.

10. The method of one of claims 6 through 9, wherein the performing of the defect management comprises:

updating temporary management information in the second temporary defect management area whenever a predetermined number of clusters in the user data area are filled or whenever verify-after-write is completed a predetermined number of times; and

updating temporary management information in the first temporary defect management area whenever a recording operation is completed.

11. The method of one of claims 6 through 9, wherein the performing of the defect management comprises writing the most update temporary management information in the first or second temporary defect management area to a defect management area provided in at least one among the lead-in area, the lead-out area,
5 and the outer areas of the write-once disc.

12. A disc drive comprising:
a pickup which writes data to or reads data from a disc; and
a control unit which verifies data that is written to or read from the disc by the
10 pickup, performs defect management using a plurality of temporary defect management areas provided on the disc, and when one among the plurality of temporary defect management areas is exhausted, controls the pickup to write full flag information indicating that the one temporary defect management area is exhausted to at least one among remaining temporary defect management areas.

13. The disc drive of claim 12, wherein the control unit performs the defect management using the remaining temporary defect management areas.

14. The disc drive of claim 12, wherein at least one among the plurality of
20 temporary defect management areas is disposed in at least one among a lead-in area, a lead-out area, and an outer area of the disc, and at least one among the plurality of temporary defect management areas is disposed in a data area of the disc.

15. The disc drive of claim 14, wherein when one among temporary defect
25 management areas disposed in at least one among the lead-in area, the lead-out area, and the outer area is exhausted, the control unit controls the pickup to write full flag information indicating that the one temporary defect management area is exhausted to at least one among temporary defect management areas disposed in the data area.

16. The disc drive of claim 15, wherein when one among the temporary defect management areas disposed in the data area is exhausted, the control unit controls the pickup to write full flag information indicating that the one temporary defect management area is exhausted to at least one among the temporary defect management areas disposed in at least one among the lead-in area, the lead-out area, and the outer area.

17. A write-once disc having a single recording layer on which a lead-in area, a data area, and a lead-out area are sequentially disposed, the data area having a first spare area, a user data area, and a second spare area which are sequentially disposed, the write-once disc comprising:

a defect management area provided in at least one of the lead-in area and the lead-out area to write defect management information;

a first temporary defect management area provided in at least one of the lead-in area and the lead-out area to write temporary management information with a predetermined period; and

a second temporary defect management area provided between the first spare area and the user data area or between the user data area and the second spare area to write temporary management information with a different period from the predetermined period,

wherein full flag information indicating whether the second temporary defect management area is exhausted is written to the first temporary defect management area, and full flag information indicating whether the first temporary defect management area is exhausted is written to the second temporary defect management area.

18. A write-once disc having a first recording layer and a second recording layer, the first recording layer including a lead-in area, a data area, and an outer area which are sequentially disposed according to a recording path wherein the data area has a first spare area and a second spare area at the respective opposite ends thereof,

the second recording layer including an outer area, a data area, and a lead-in area which are sequentially disposed according to the recording path wherein the data area has a third spare area and a fourth spare area at the respective opposite ends thereof, the write-once disc comprising:

5 a defect management area provided in at least one among the lead-in area, the lead-out area, and the outer areas to write defect management information;

 a first temporary defect management area provided in at least one among the lead-in area, the lead-out area, and the outer areas to write temporary management information with a predetermined period; and

10 a second temporary defect management area provided between the first spare area and the user data area and/or between the fourth spare area and the user data area to write temporary management information with a different period from the predetermined period,

 wherein full flag information indicating whether the second temporary defect management area is exhausted is written to the first temporary defect management area, and full flag information indicating whether the first temporary defect management area is exhausted is written to the second temporary defect management area.

19. The write-once disc of claim 17 or 18, wherein the temporary management information in the second temporary defect management area is updated whenever a predetermined number of clusters in the user data area are filled or whenever verify-after-write is completed a predetermined number of times.

20. The write-once disc of claim 17 or 18, wherein the temporary management information in the first temporary defect management area is updated whenever a recording operation is completed.

21. The write-once disc of claim 17 or 18, wherein the most update temporary management information in the first or second temporary defect management area is

written to the defect management area when the write-once disc is finalized.

FIG. 1

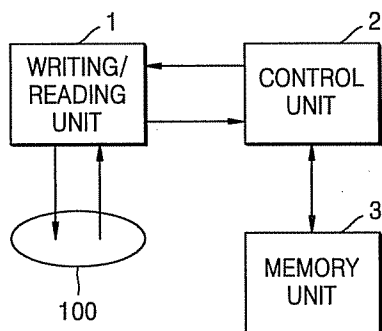


FIG. 2

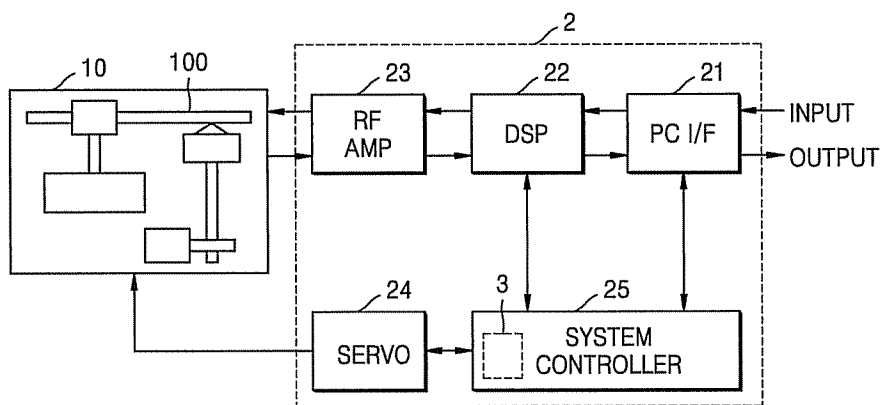


FIG. 3A

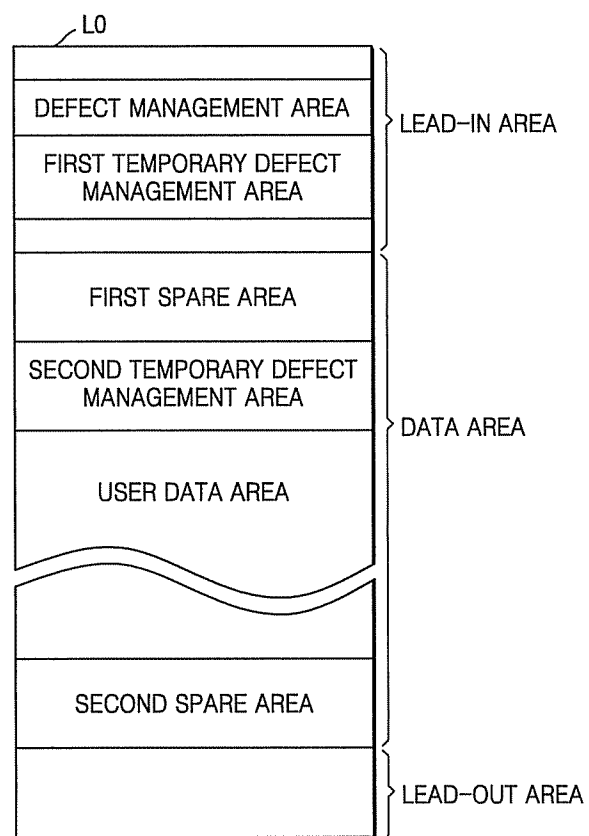


FIG. 3B

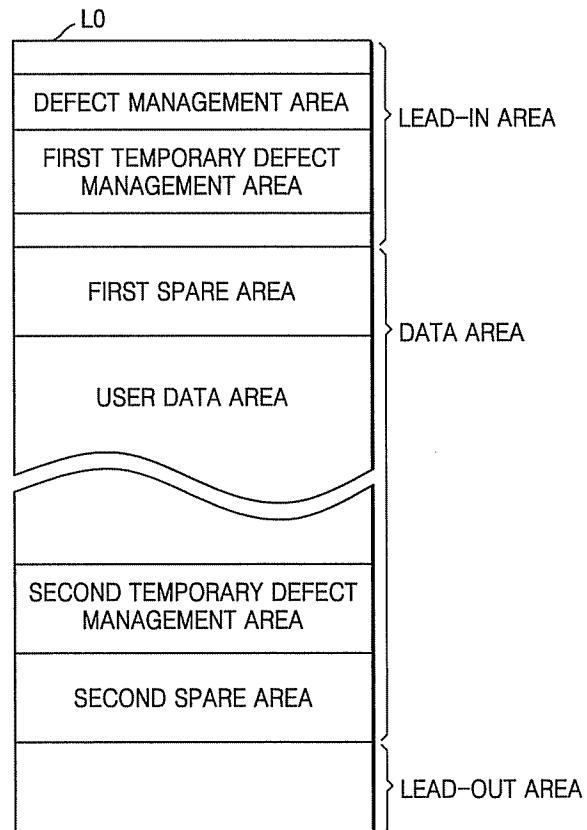


FIG. 4

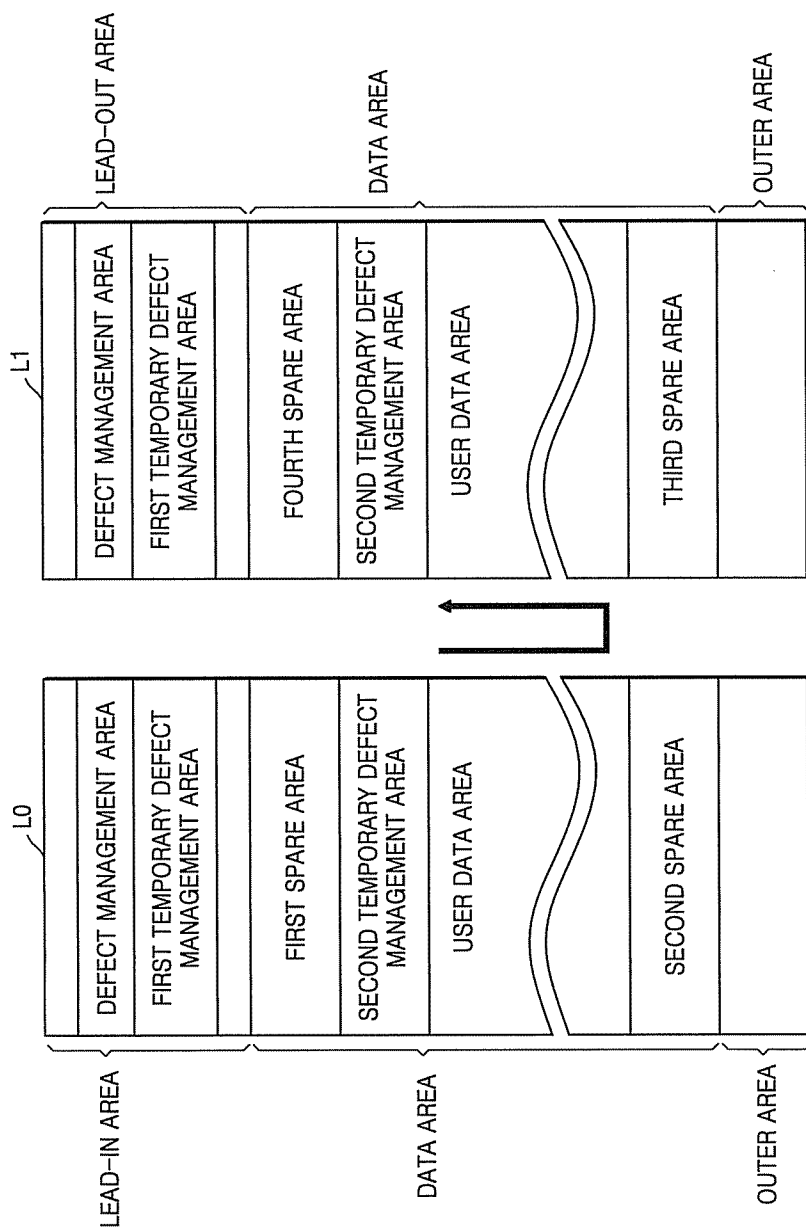


FIG. 5A

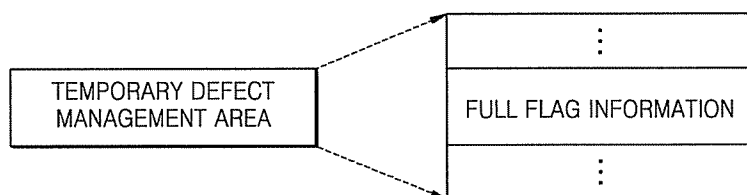


FIG. 5B

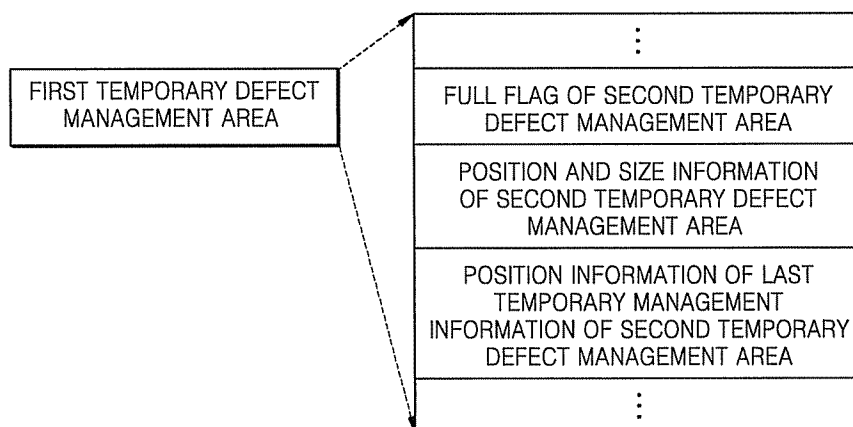


FIG. 6A

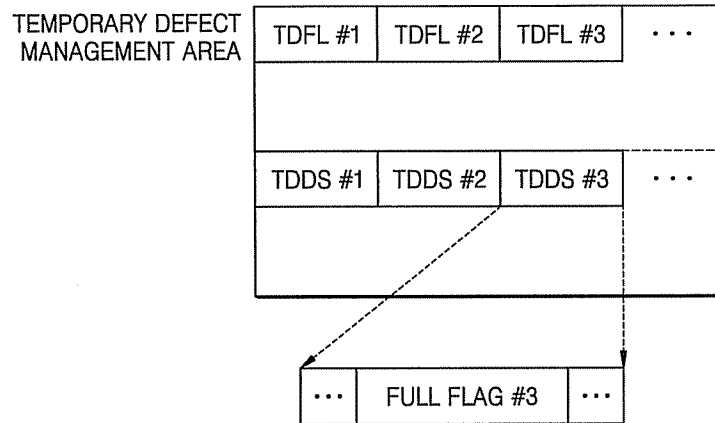


FIG. 6B

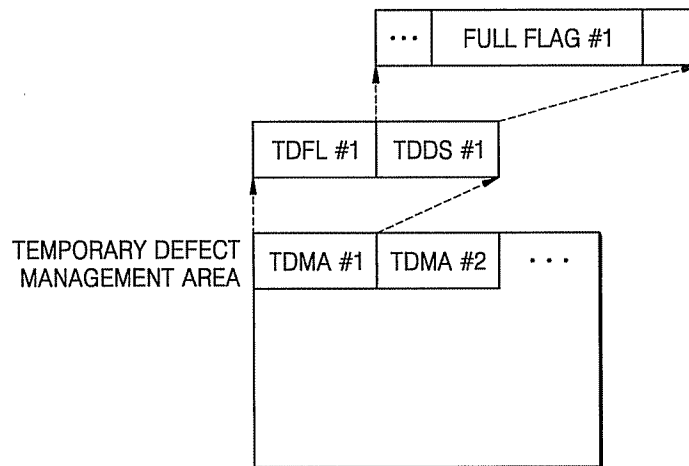


FIG. 7

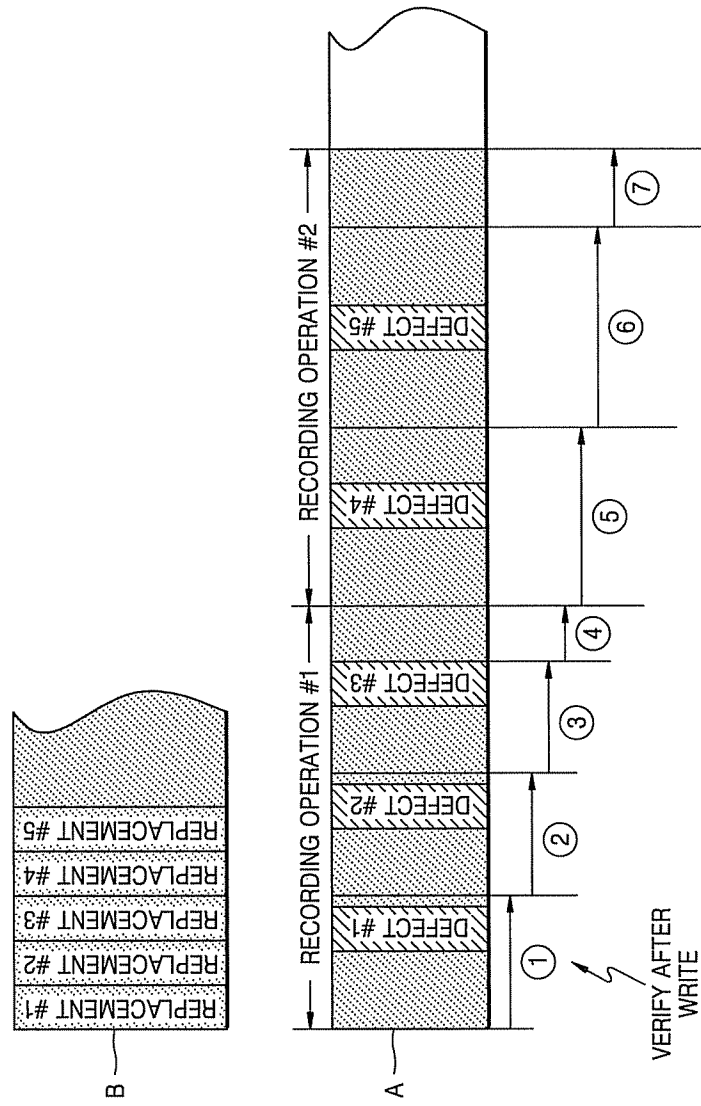


FIG. 8

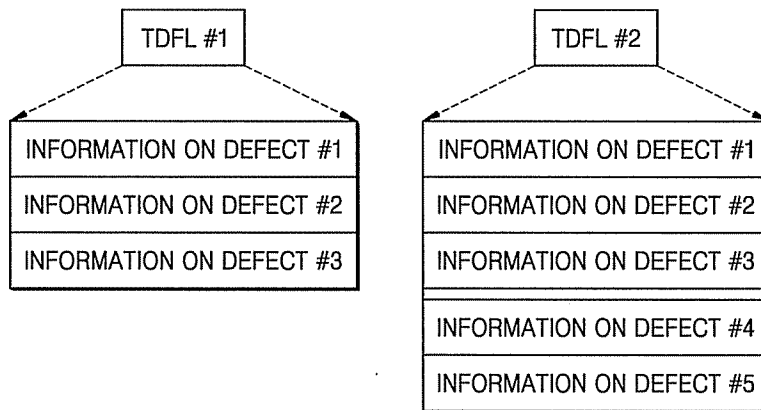


FIG. 9

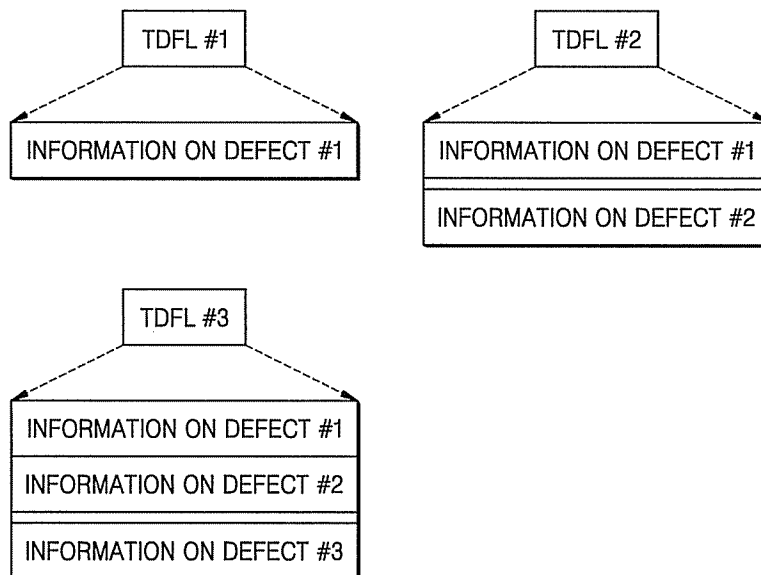


FIG. 10

